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AIRFLOW DISTRIBUTIONS IN 9 EAST LONGWALL

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AIRFLOW DISTRIBUTIONS IN 9 EAST LONGWALL

by

A.W. Stokes* and G. Corbett**

SUMMARY

This report documents the results of three airflow surveys conducted in 9 East longwall, Langan Colliery during late June 1986. Tracer gas was used to measure the gob leakage flows onto and off the face.

These results provided the calibration data for the fixed airflow sensors of a CONSPEC mine telemetry system and additional information to support an extensive investigation of methane release patterns in the 9 East longwall.

The time taken for a gob injection of sulphur hexafluoride to reach the return fireseal via the airstream in the roadway and the methane drainage line were measured. This information provides an insight into the airflow patterns through the gob close to the working face.

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DISTRIBUTIONS DU FLUX D'AIR DANS LA GALERIE 9 D'EXPLOITATION EN LONGUE TAILLE

par

A.W. Stokes* et G. Corbetts**

RÉSUMÉ

Dans ce rapport, sont documentés les résultats de trois relevés du flux d'air, effectués dans la galerie 9 d'exploitation en longue taille, dans la mine de charbon Langan, à la fin du mois de juin 1986. On a utilisé un gaz traceur, pour mesurer le débit des fuites survenant dans les espaces déhouillés, sur le front de taille et à partir de celui-ci.

Des résultats obtenus, on a déduit des données destinées à l'étalonnage des capteurs fixes de flux d'air d'un réseau télémétrique minier CONSPEC, et de l'information additionnelle destinée à une vaste étude des voies de dégagement du méthane dans la galerie 9 East d'exploitation en longue taille.

On a mesuré le temps nécessaire à une quantité d'hexafluorure de soufre injectée dans un espace déhouillé pour parvenir jusqu'au registre coupe-feu en suivant le flux d'air le long de la chaussée et dans les conduites de drainage du méthane. Cette information nous permet de mieux comprendre les modes de circulation de l'air à travers les espaces déhouillés à proximité du front de taille.

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INTRODUCTION

Researchers from the United States Bureau of Mines (USBM) have developed instrumentation and an investigational protocol suitable for defining the parameters of methane release on the coalface of a working longwall. Using their equipment, researchers at the Cape Breton Coal Research Laboratory (CBCRL) undertook a comprehensive longwall methane survey of the 9 East panel in Lingan Colliery during June and July of 1986. This was intended not only to define the face release, but also the release patterns throughout the longwall. A more detailed description of these surveys is reported elsewhere (1).

CBCRL's ventilation group provided support to this investigation by measuring the airflow quantities and flow patterns in and around the longwall. An accurate determination of these values are essential in any meaningful evaluation of the methane flows. Nine East has been the subject of an ongoing investigation into the problem of gob leakage for the previous eighteen months and as such has already had seven detailed ventilation surveys. Consequently, a substantial data base already exists for 9 East and the June ventilation surveys served to update and complement this.

This report describes the results of these most recent surveys and presents an evaluation of the overall airflow distribution and flows in 9 East longwall.

EXISTING DATA

Nine East longwall was started in 1984. The first 640 m of advance was completed with conventional wooden packing on the gobside of the intake gateroad. From 640 m inbye to the face (presently +1600 m in), a monolithic pack has been used instead. This has significantly reduced the air leakage through the gob between the intake and return gateroads. A total of seven ventilation surveys have been completed to measure the gob leakage in 9 East and determine the improvement due to the monolithic packing (2). From these surveys, a considerable data base exists on the airflow patterns in the main part of the collapsed gob. Figure 1 shows a typical airflow profile measured in the return gateroad and Figure 2 shows the resistance of the gob corridors as measured during the same survey. From Figure 1 it can be seen that although not eliminated the gob leakage through the monolithic packed section

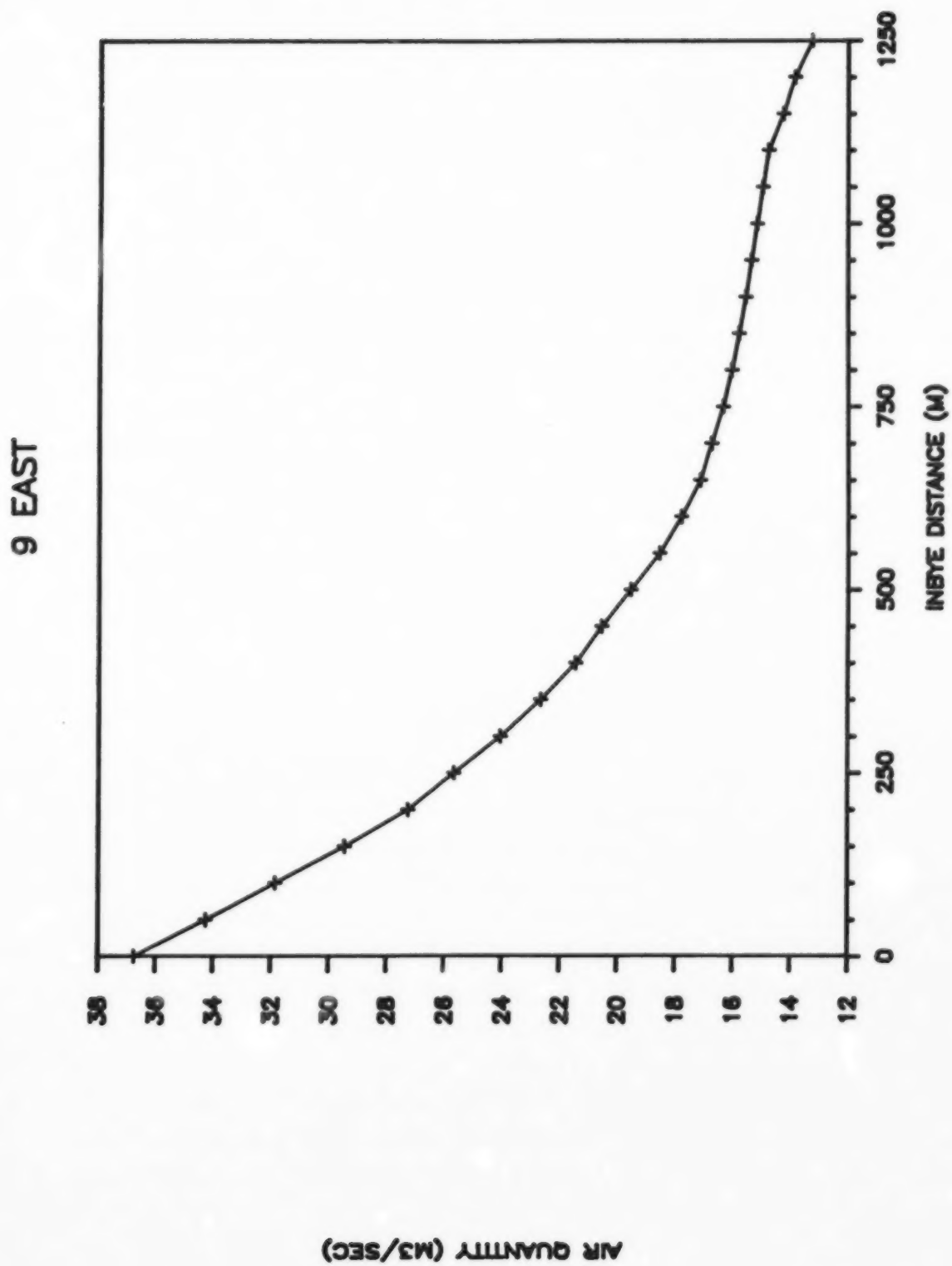


Figure 1 - Airflow profile measured in 9 East return gateroad

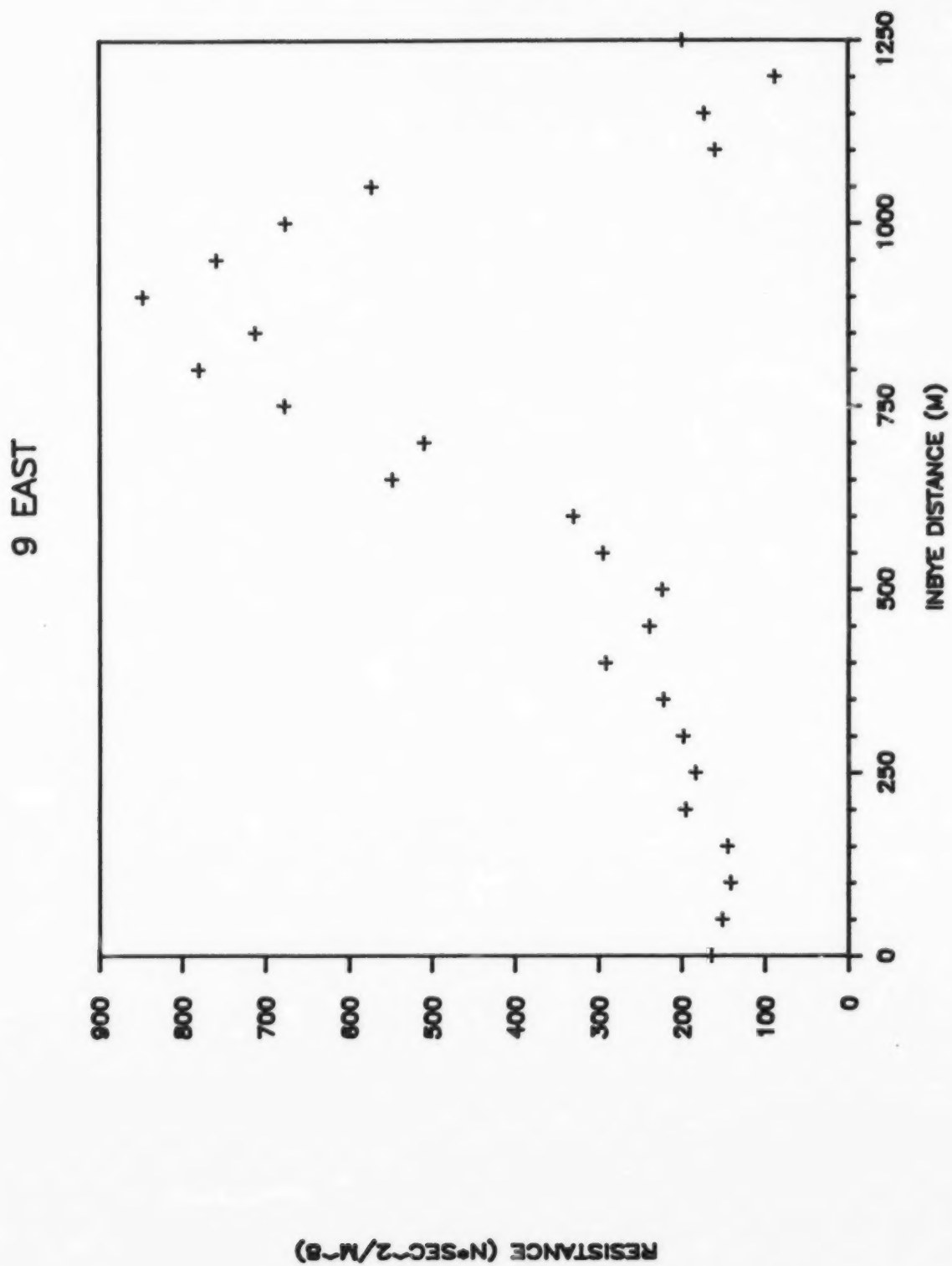


Figure 2 - Gob corridor resistances measured in 9 East longwall

of 9 East is considerably less than through the conventionally packed section. This is reflected by looking at Figure 2 which shows the corresponding increased resistance of the gob corridors.

The objective of the June ventilation survey was to update this information and to investigate in more detail the ventilation airflows in and around the face. As a by-product, an attempt was also made to determine the airflow pattern through the gob and into the methane drainage line.

SURVEY METHODOLOGY

The June survey consisted of two parts. The first was a repeat of previous surveys which measured the airflows in the return gateroad and the differential pressures around the longwall. The techniques used to do this are described elsewhere (3). Figures 3 and 4 show the results obtained from this part of the investigation; an updated version of Figures 1 and 2. Figure 5 is included as a reference and show the results of the differential pressure survey.

Figure 3 shows that the return gateroad airflow profile remained essentially the same as before with a reduced amount of gob leakage through the monolithic packed section. The irregular flow patterns close to the face were becoming increasingly obvious with the leakage associated with it detectable as far back as 300 m. When a comparison is made with the profile in Figure 1, it is apparent that this 'face effect' moves in with the face.

Figure 4 shows the gob corridor resistances for the 9 East panel as of June 24. These are consistent with what has been measured previously, with a significant increase in the gob corridor resistance along the monolithic packed section. The apparent drop in resistance close to the face is again attributable to the 'face effect' and not a true reflection of the resistance of the gob.

TRACER GAS INJECTION INTO THE GOB

The second part of the survey was a more detailed investigation of the airflows through the gob close to the face. A tracer gas (sulphur hexafluoride) was injected into the gob immediately behind the packhole on the intake side of the face (see Figure 6). It was a continuous release from a lecture bottle at a flow rate of 0.762 ml/s. Air samples were collected from the general airbody and the methane drainage line at the return gateroad

LINGAN MINE 9 EAST TRACER GAS SURVEY

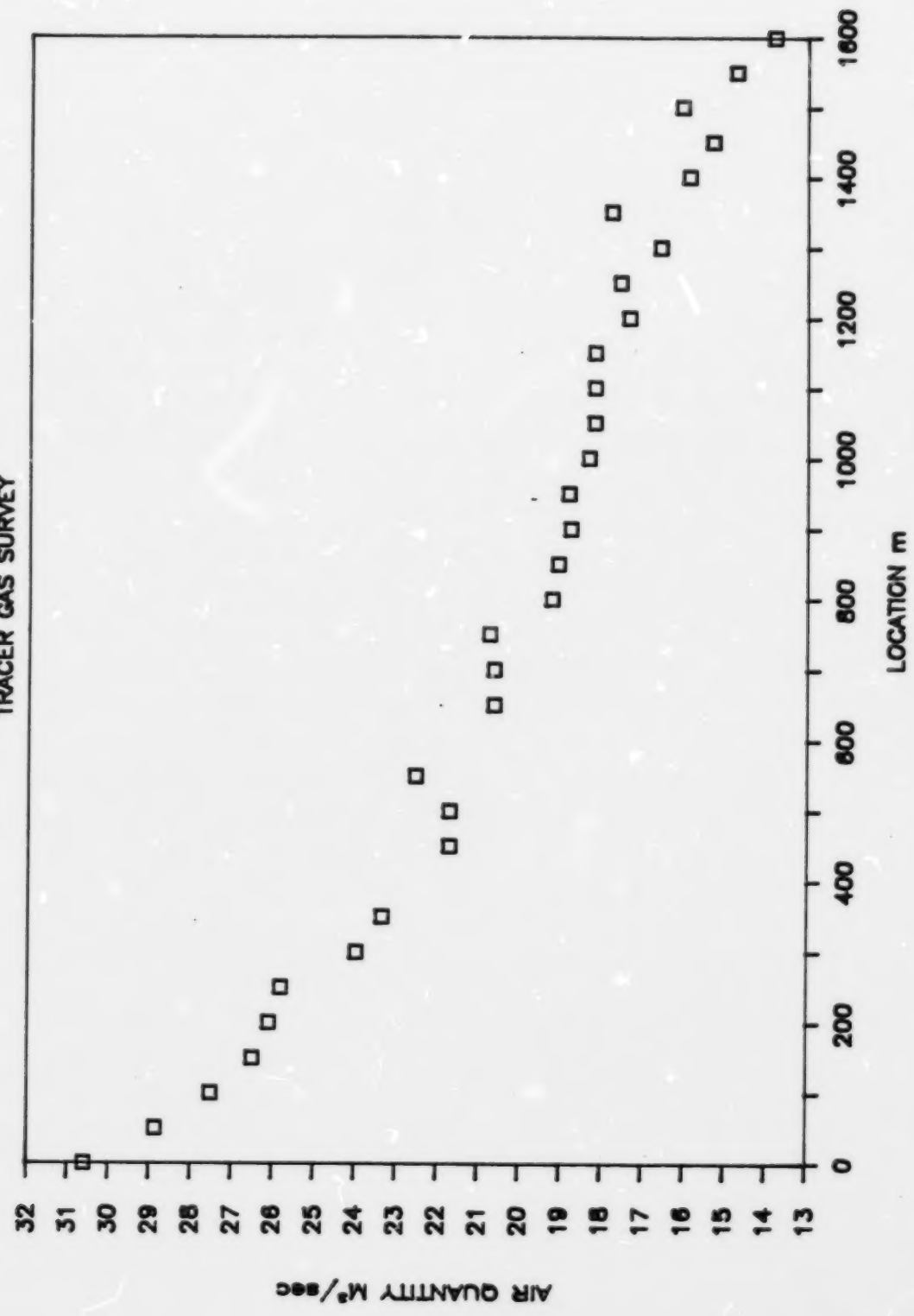


Figure 3 - Airflow profile measured in 9 East return gateroad (June 24)

LINGAN 9 EAST LONGWALL, JUNE 24

RESISTANCE .VS. DISTANCE

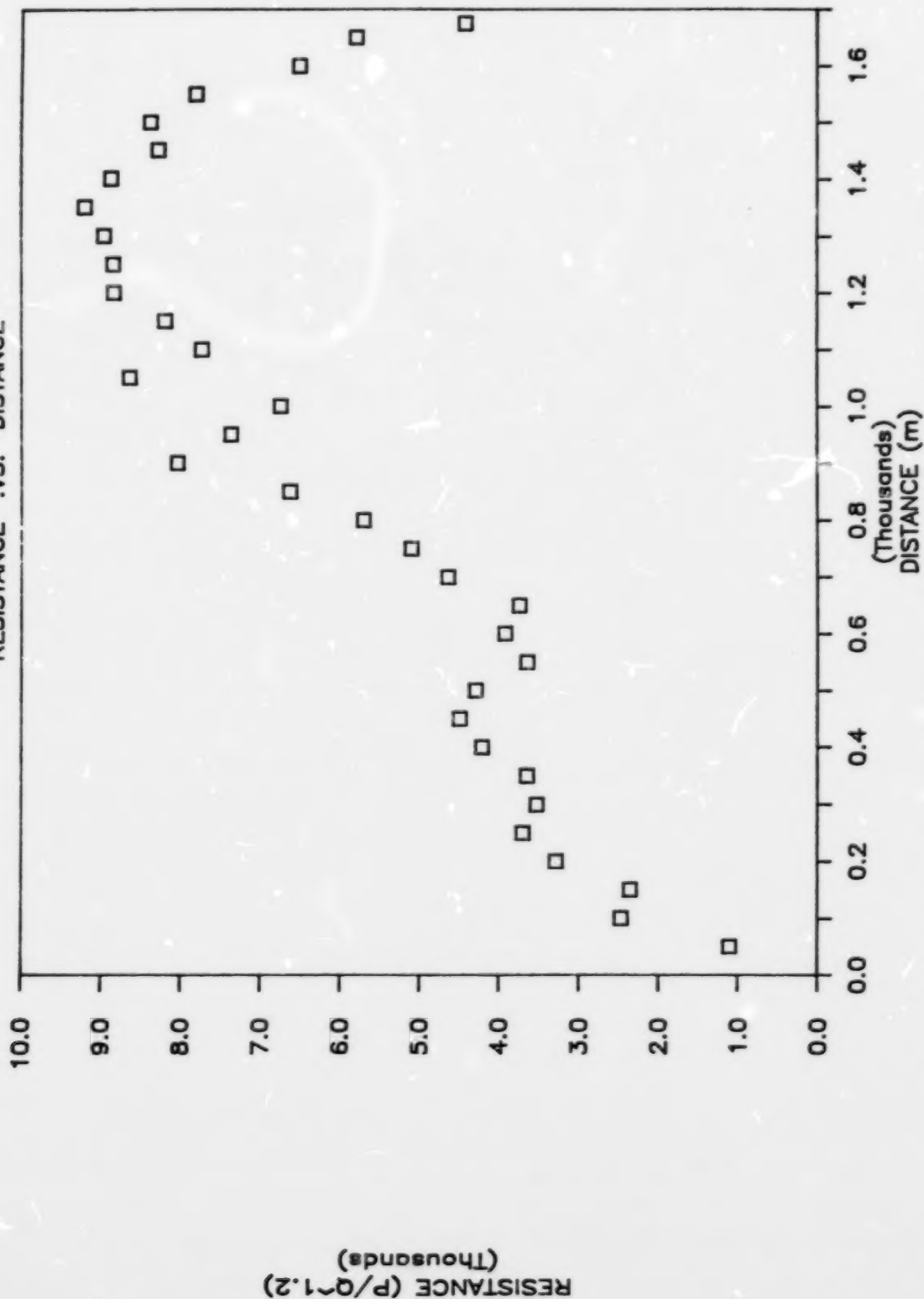


Figure 4 - Gob corridor resistances measured in 9 East longwall (June 24)

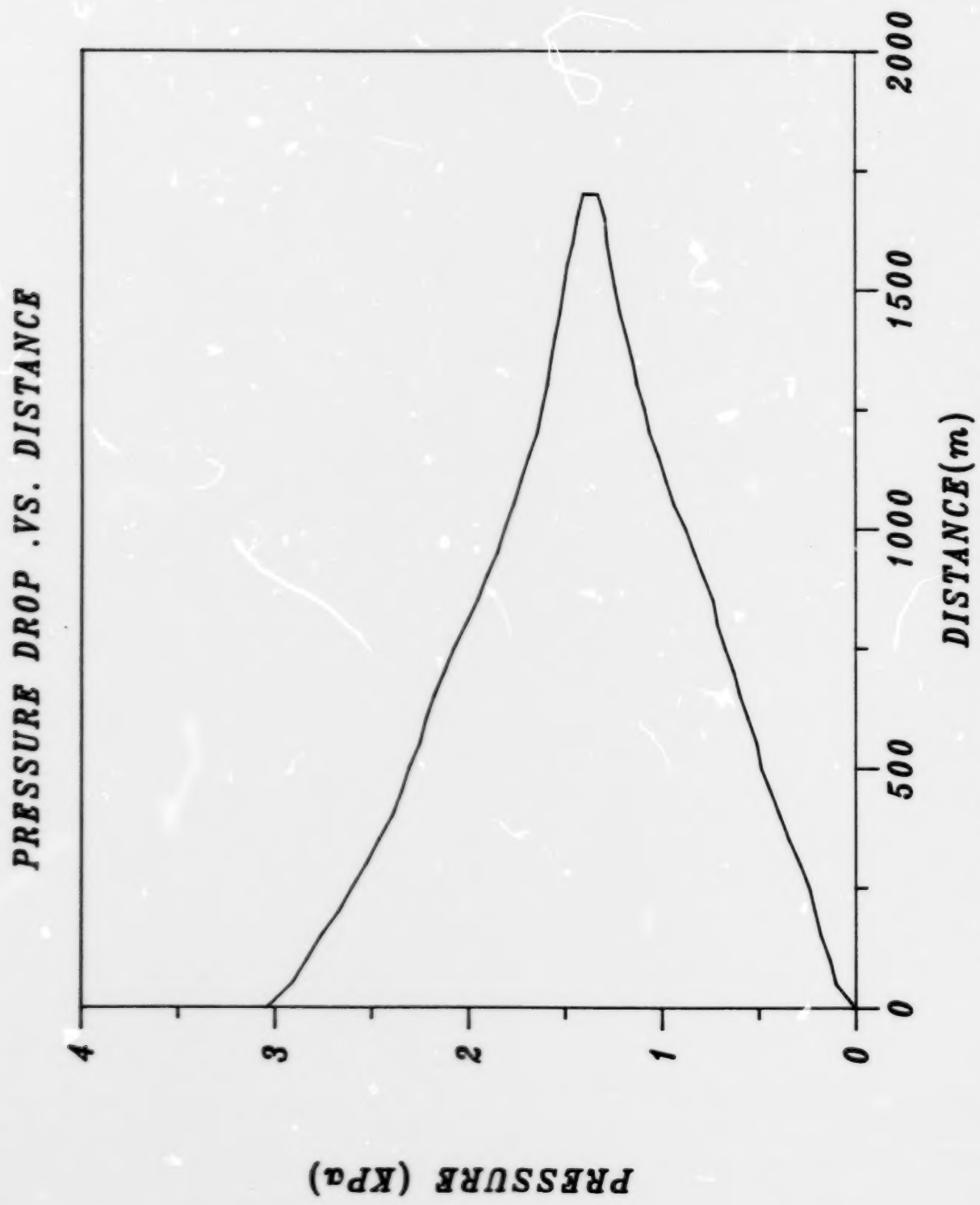


Figure 5 - Differential pressure profile around 9 East longwall

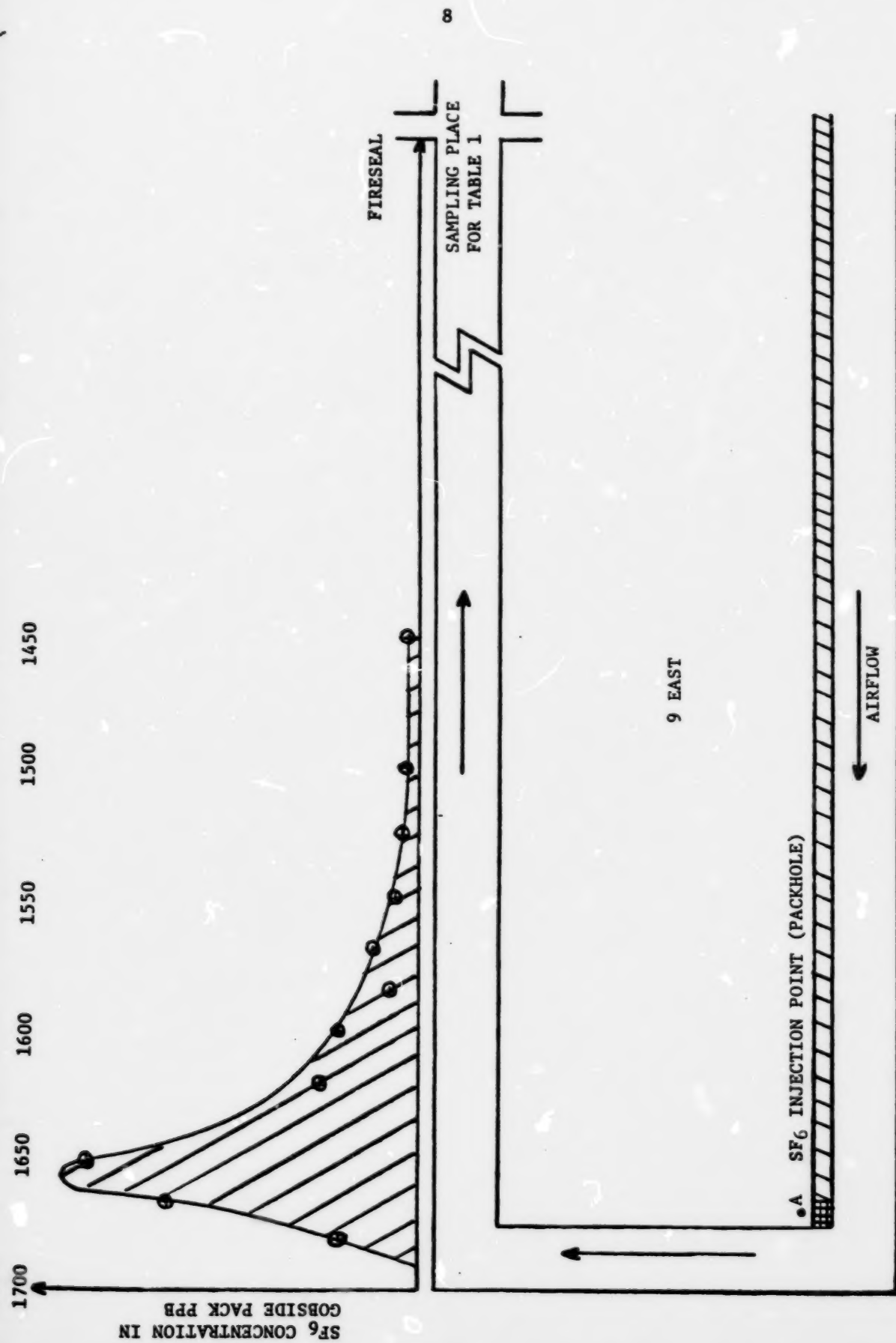


Figure 6 - Schematic representation of 9 East showing SF₆ injection and sampling points

fireseal. These were taken at 15-minute intervals commencing about the time of the start of the tracer gas release and continued for more than four hours. This was the amount of time estimated that would be required for the tracer gas to reach steady state concentrations throughout the longwall. Table 1 lists the results of the laboratory analysis for the concentrations of tracer gas in the samples collected at the return fireseal.

Once steady state was thought to have been reached, samples were then drawn from the perimeter of the gob close to the return gateroad and immediately behind the shield supports on the face. In addition, samples were collected from the face airstream and from four sampling valves along the methane drainage line close to the face. The relative positions at which these samples were collected are marked onto Figure 6 and the concentrations of SF_6 contained in them are given in Table 2.

GENERAL AIRBODY CONCENTRATIONS AT RETURN FIRESEAL

Figure 7 shows a graph of the concentrations of SF_6 measured in the samples collected at the return fireseal versus time. This build up is different from previous ones recorded with gob injections further back from the face in that it is much more rapid. Usually the tracer gas takes three to four hours to move through the collapsed gob whereas in this case the t_{50} concentration was reached at the fireseal less than half an hour after the start of the injection. This indicates that either most of the gas was being swept directly into the face airstream or that it was being carried along in a major airstream immediately behind the shield supports (and/or a combination of these two things).

An approximate value for the average travel time along the return gateroad can be calculated from Figure 3. The average air quantity flowing through the return roadway was $18 \text{ m}^3/\text{s}$. Assuming that the average cross-sectional area was approximately 7 m^2 , then the average velocity of the air moving through the roadway was 2.6 m/s . Therefore for the 1700 m of return, the air's travel time was 11 minutes. A similar calculation can be done for the air's travel time along the face. This works out to be approximately 2 minutes. From these two times it would seem that the tracer gas was carried in a combination of these two airstreams.

From anemometry measurements made at the fireseal, it was calculated that the steady state concentration of SF_6 should have been 26.3 ppb .

Table 1 - Results of SF₆ concentration in samples
collected at the return fireseal

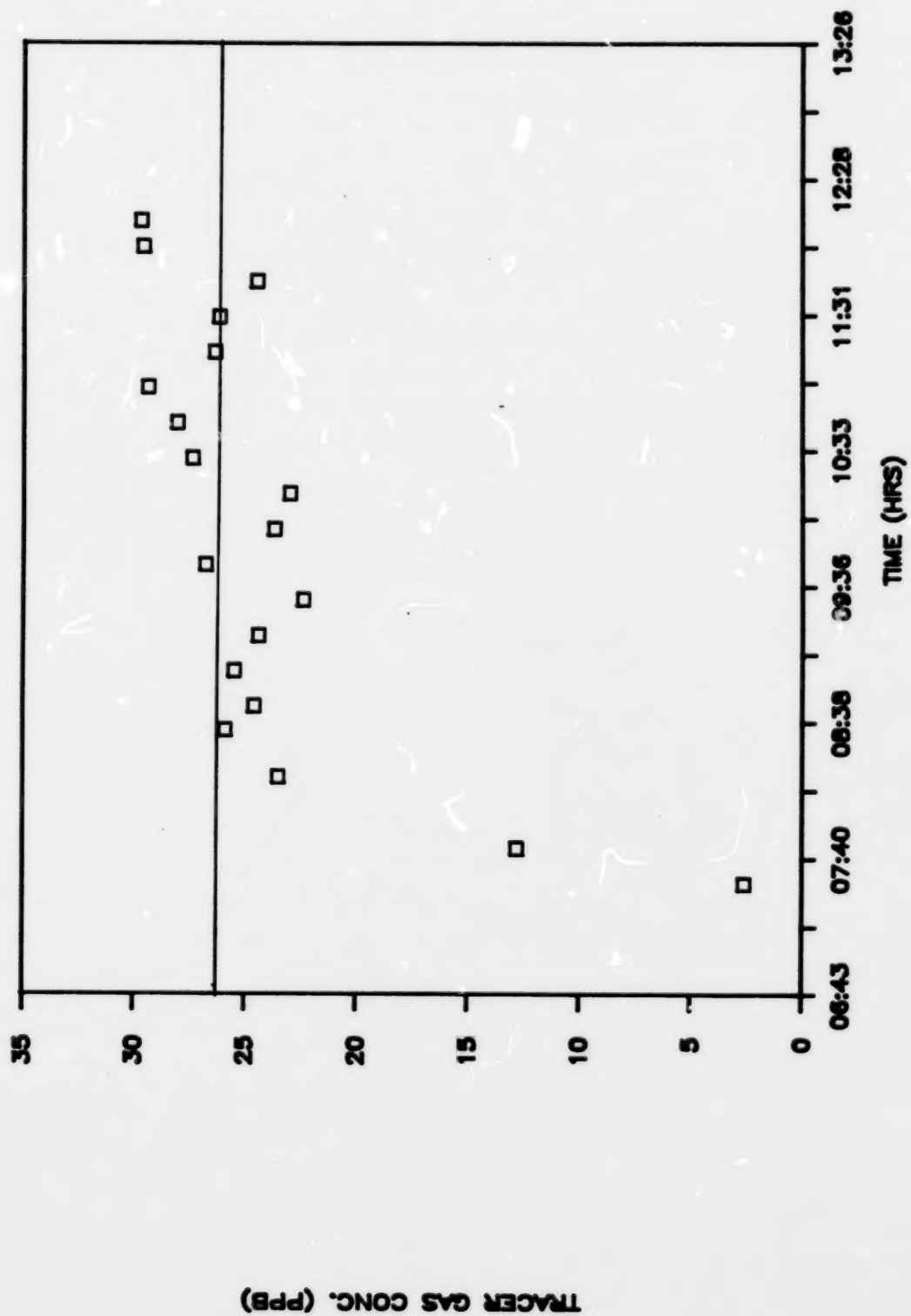
Bag #	Sample Location	Time	Peak Height and Scale	Concentration
1	-	-	-	-
2	Methane Drainage	0655	3	0.2
3	-	-	-	-
4	-	-	-	-
5	Methane Drainage	0723	2	0.1
6	-	-	-	-
7	Methane Drainage	0735	1	2.6
8	-	-	-	-
9	Methane Drainage	0750	16	1.0
10	-	-	-	-
11	Methane Drainage	0805	28	1.8
12	Fireseal	0815	364	23.5
13	Methane Drainage	0820	32	2.1
14	Fireseal	0835	401	25.9
15	Methane Drainage	0840	33	2.1
16	Fireseal	0845	380	24.6
17	Methane Drainage	0850	30	1.9
18	Fireseal	0900	394	25.5
19	Methane Drainage	0905	25	1.6

Table 1 - Cont'd

Bag #	Sample Location	Time	Peak Height and Scale	Concentration
20	Fireseal	0915	378	24.4
30	Methane Drainage	0920	31	2.0
31	Fireseal	0930	397	22.4
32	Methane Drainage	0935	36	2.3
33	Fireseal	0945	415	26.8
34	Methane Drainage	0950	30	1.9
35	Fireseal	1000	367	23.7
36	Methane Drainage	1005	42	2.7
37	Fireseal	1015	356	23.0
38	Methane Drainage	1020	36	2.3
39	Fireseal	1030	424	27.4
40	Fireseal	1045	436	28.1
41	Fireseal	1100	455	29.4
42	Fireseal	1115	408	26.4
43	Fireseal	1130	405	26.2
44	Fireseal	1145	379	24.5
45	Fireseal	1200	458	29.6
46	Fireseal	1211	460	29.7
47	Methane Drainage	1213	134	8.6
48	Methane Drainage	1214	131	8.5

Table 2 - SF₆ concentrations in samples collected near 9 East face

Bag #	Sample Location	Time	Peak Height and Scale	Concentration
49	-	-	-	-
50	Behind Shield #112	1057		
51	Face Airflow #112	1059	64	9.6
52	Behind Shield #130	1103	446	66.5
53	1665 m inbye (20 m back)	1107	Off Scale	207.4
54	1650 m inbye	1110	Off Scale	256.7
55	1635 m inbye	1112	982	146.5
56	CH ₄ Hole #1	1116	67	10.0
57	1620 m inbye	1118	564	84.2
58	CH ₄ Hole #2	1120	11	1.64
59	1600 m inbye	1125	405	60.4
60	1585 m inbye	1127	200	29.8
61	CH ₄ Hole #3	1129	9	1.3
62	1570 m inbye	1132	302	45.1
63	CH ₄ Hole #4	1134	4	0.6
64	1550 m inbye	1137	136	20.3
65	1525 m inbye	1139	81	12.1
66	1500 m inbye	1141	52	7.8
67	1450 m inbye	1143	47	7.0
68			-	
69			-	

Figure 7 - SF₆ concentrations measured at the return fireseal versus time

This is marked onto the graph in Figure 7. The SF_6 concentrations measured at the fireseal fluctuated with time. As can be seen, values lie either side of the predicted steady state concentration. This is unlike previous surveys where once the return fireseal tracer concentrations had risen to steady state they remained virtually unchanged. From the author's knowledge of what happened in the longwall during the survey, there is no ready explanation for this.

CONCENTRATIONS IN THE METHANE DRAINAGE LINE

Figure 8 shows a graph of the SF_6 concentrations measured in the methane drainage line at the return fireseal versus time. Unfortunately no samples were collected between 1020 hrs and 1215 hrs and so it is questionable how the concentration rose from 3 to 8.5 ppb. After a gradual rise in the SF_6 concentration to 2.0 ppb, it remained virtually steady for almost 2 hours, from 0800 hrs to 1000 hrs. Then between 1000 hrs and 1215 hrs there was a large increase to 8.5 ppb. This stepped increase in the concentration must have been due to two or more discrete flowpaths of SF_6 into the methane drainage line. This was probably the difference in time taken for an airflow to reach two or more of the methane drainage holes on suction. However as to which holes these were is open to speculation.

As will be shown in the next section, it would seem that the concentrations in the methane drainage line were not near to steady state and fireseal values would have risen a lot higher with time.

CONCENTRATIONS IN AND AROUND THE WALLFACE

Table 2 lists the concentrations of SF_6 measured in the samples collected from the general airbody, methane drainage line and the perimeter of the gob near to the wallface. These results are shown on a schematic representation of 9 East wallface in Figure 6.

A concentration of 9.6 ppb was measured in the face airflow near to support No. 112 (approximately 168 m from the intake). The face airflow at this point was $13 \text{ m}^3/\text{s}$ so that the total volume of SF_6 in the face airstream was:

$$9.6 \times 10^{-9} \times 13 \times 10^6 = 0.1235 \text{ ml/s}$$

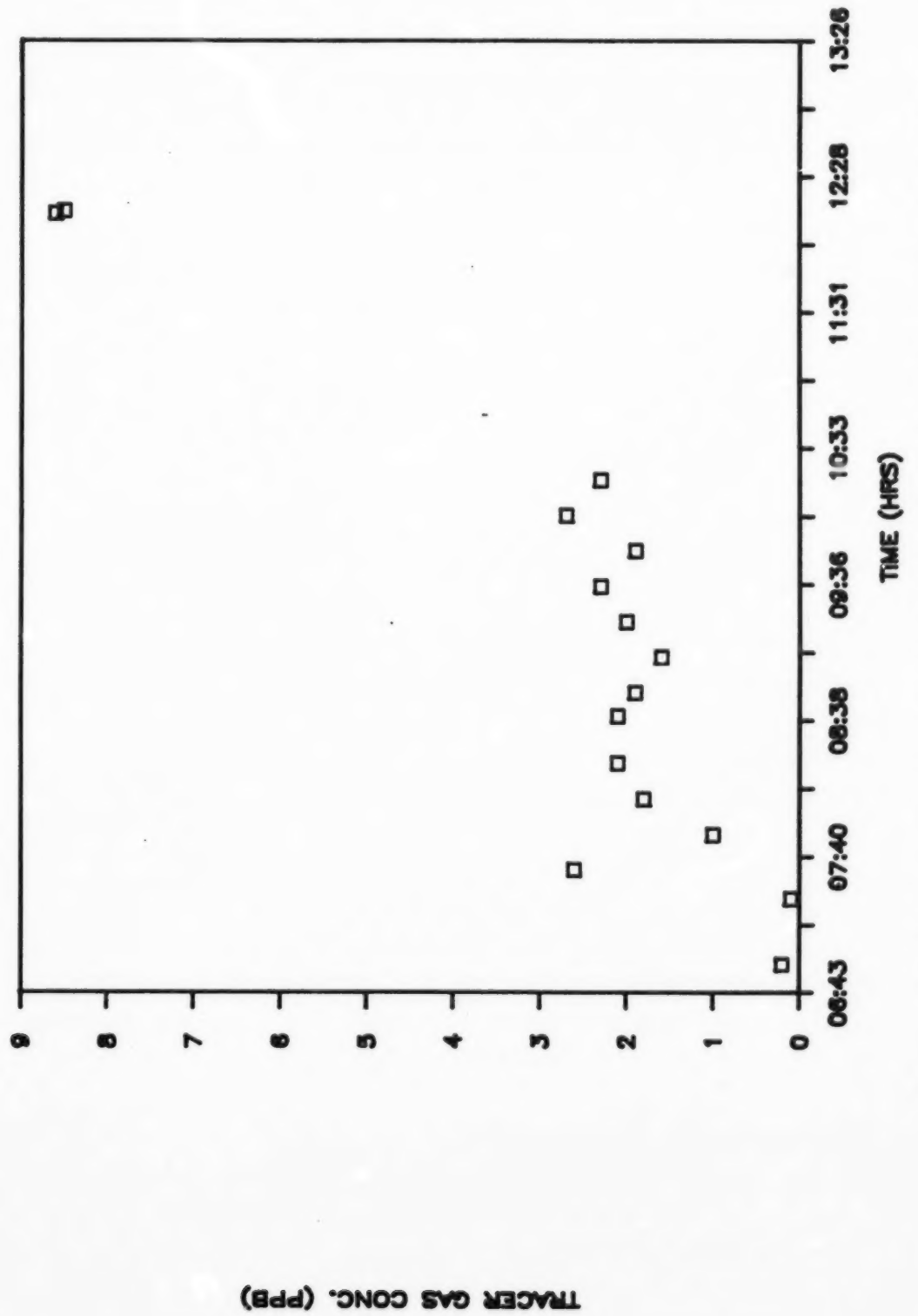


Figure 8 - SF_6 concentrations measured in the methane drainage line versus time

This represents 16.2 percent of the total volume of SF_6 released at the packhole $[(0.1235 \times 100)/0.7622\%]$ and would indicate that there was only a small leakage of air from behind the face supports onto the face between the intake packhole and support No. 112. More than 80 percent of the gas therefore passed through the gob to be removed from the district by either the return gateroad airflow or the methane drainage line. As already mentioned, a large proportion of the gas was measured at the return fireseal shortly after the initial release. Negating the 16 percent that returned via the faceline, the average travel time for the remainder of the airborne gas was approximately 30 minutes. Deducting the time taken to travel along the return gateroad gives a residence time in the gob of about 18 minutes. Assuming that the flowpath was parallel to the face, the velocity of this airstream was 0.2 m/s. This would be indicative of an open area with a significant airflow through it. Judging by where this gas was measured entering the return gateroad (see Figure 6) it would seem that the most likely location for this open channel would be the area immediately behind the shield supports. This could be caused by either loose consolidation of the collapsed gob on an open non-caved section.

Figure 6 shows the SF_6 concentrations measured in between the return gobside packs. The maximum concentration occurred about 20 m back from the face falling off outbye towards the return fireseal. Samples were collected as far back as 250 m behind the wallface in which there were measurable concentrations of SF_6 .

In all likelihood the SF_6 moved along a major flowpath behind the shield supports and then when it approaches the return end of the face a portion of it is swept into the gob by leakage of air from the face. This phenomena has been recorded in previous surveys on 9 East.

This theory is verified by the concentration of gas measured behind shield support No. 112 (66.5 ppb). This was substantially lower than the concentration measured 20 m back from the face suggesting that fresh air from the faceline was moving back into the gob and diluting it.

GENERAL COMMENTS AND CONCLUSIONS

A good knowledge of the airflow movements through all parts of the gob and coalface is essential in understanding the methane emissions into the general ventilation airstream.

From the large number of surveys completed on 9 East it is known that the leakage flow from the intake gateroad through the gob to the return remains relatively constant with time in a manner illustrated by Figures 1 and 3. The leakage through the gob is along a line approximately parallel to the faceline tending towards the return gateroad fireseal. Close to the face the flow patterns become disturbed with the addition of major flowpaths short circuiting the roadways from the intake onto the face and from the face onto the return.

Since the introduction of monolithic packing on the intake, leakage through the gob onto the face has been reduced appreciably. The intake leakage is now confined to the area very close to the face where the monolithic packing has not yet made a tight seal with the roof and floor.

Leakage from the face through the gob and into the return is much more evident. This has been measured as far back as 350 m from the coalface, although the majority of the leakage has entered the return within 200 m of the face. Typically this return face end leakage is 20 to 25 percent of the face airflow and so has a significant impact on methane flows near the return face end. It is probable that the methane fringe in the gob is kept far back into the gob by this large leakage flow. The interaction of this leakage flow with the short circuit which moves behind the shield supports is unclear. The fact that the lines of the flowpaths cross suggest that some interaction must occur. More investigation, probably with multiple tracer gases, is needed to better define this.

It should be understood that the flows that were measured close to the face of 9 East were only valid for the time at which they were measured. Indeed probably only valid for as long as no significant movement of the face supports were made or no significant changes to the collapsed rock behind them occurred. For a long-term methane study on a wallface the authors would suggest undertaking a number of ventilation surveys similar to these described here in order to try and determine a pattern in the airflow near to the face. Then rather than use a different set of face airflows with each survey, use the usual or average flow patterns. This approach although less precise would greatly simplify the task of gathering ventilation data underground and probably make the task of interpretation of the methane results a lot easier.

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